Current Network Security Threats: DoS, Viruses, Worms, Botnets

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Outline

- UCSD Network Telescope
- Denial-of-Service Attacks
- Viruses and Worms
- Botnets

Network Telescope

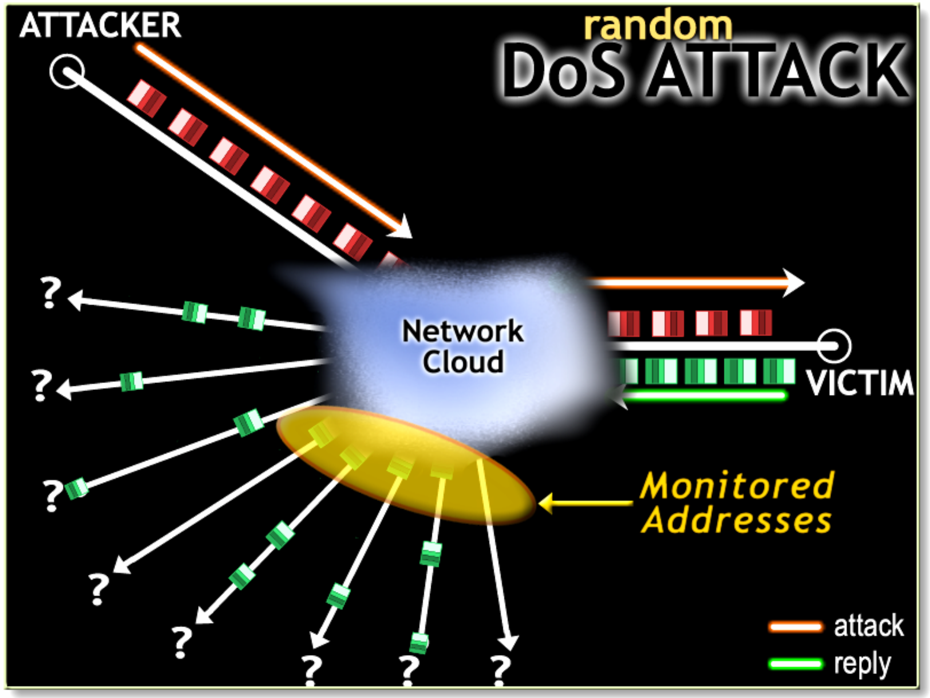
- Chunk of (globally) routed IP address space
  - 16 million IP addresses
- Little or no legitimate traffic (or easily filtered)
- Unexpected traffic arriving at the network telescope can imply remote network/security events
- Generally good for seeing explosions, not small events
- Depends on random component in spread

Network Telescope: Denial-of-Service Attacks

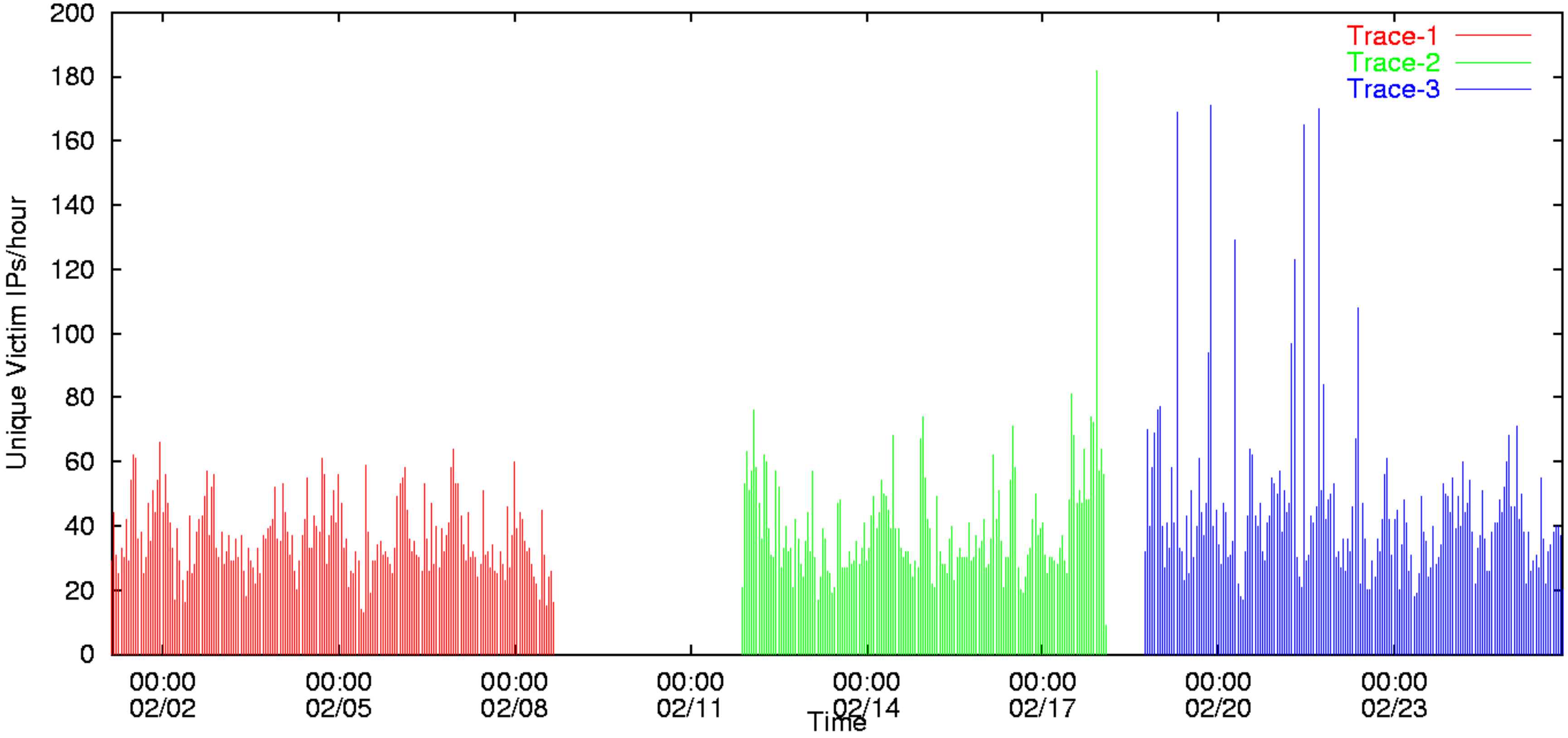
- Attacker floods the victim with requests using random spoofed source IP addresses

- Victim believes requests are legitimate and responds to each spoofed address

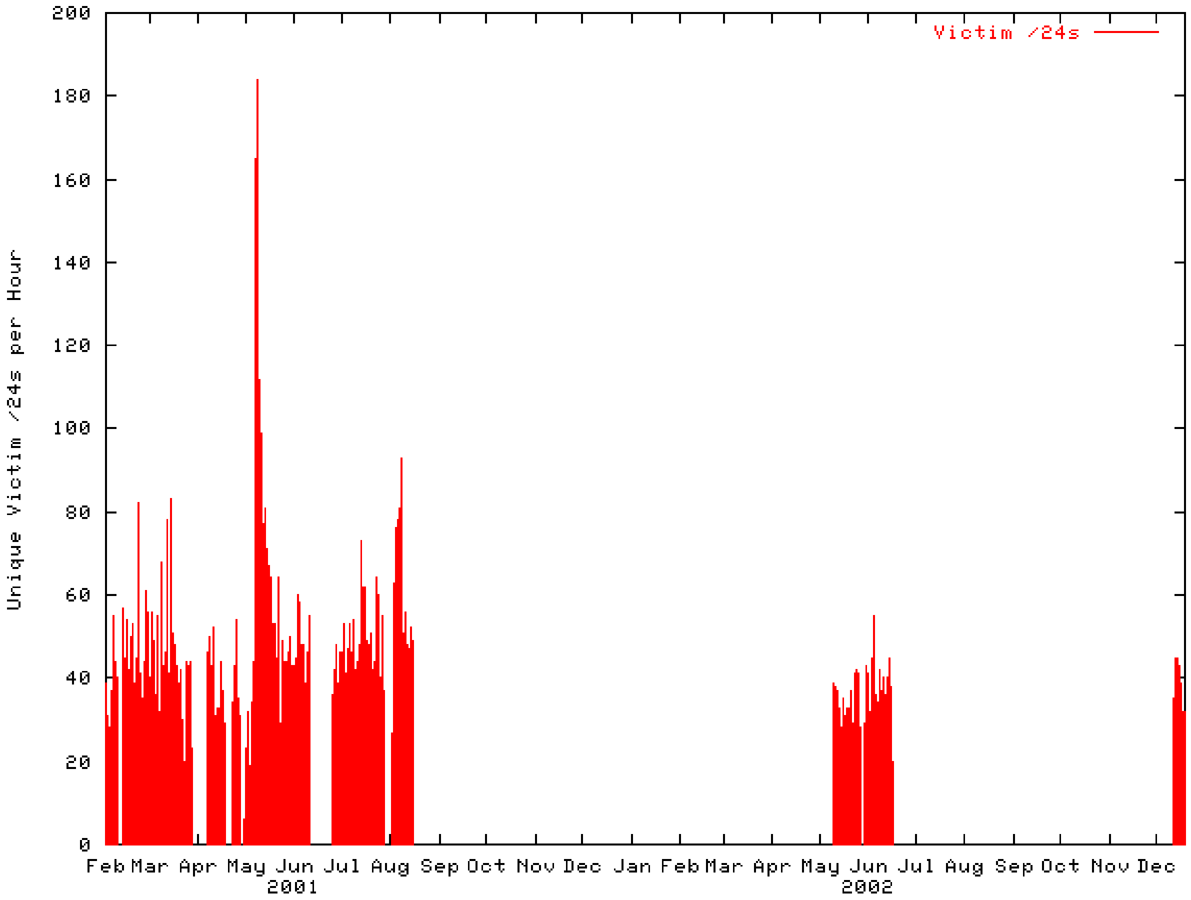
- We observe 1/256th of all *victim responses* to spoofed addresses



Denial-of-Service Attacks



DoS Attacks over time

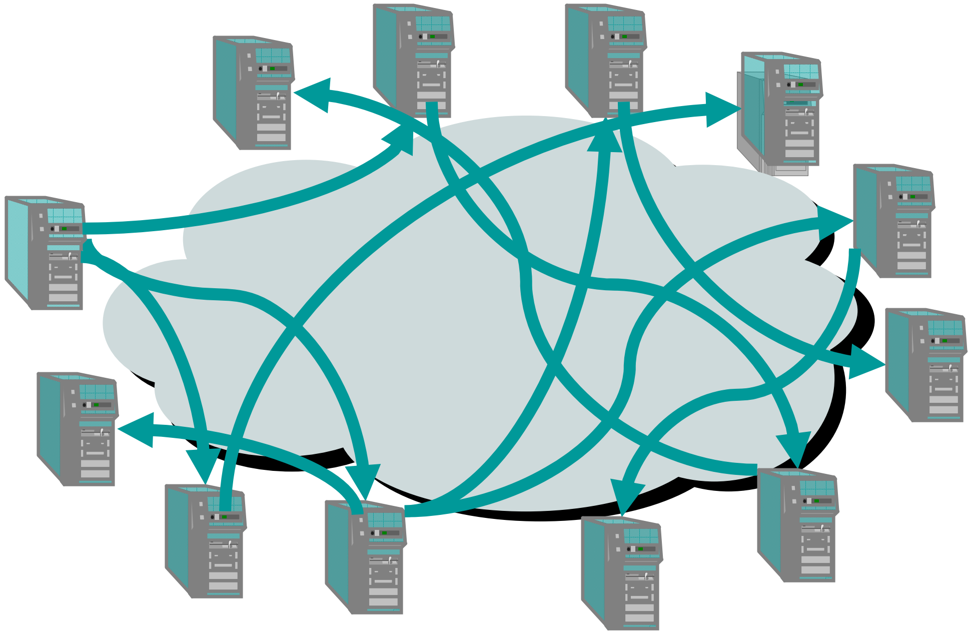


Network Telescope Observation Station

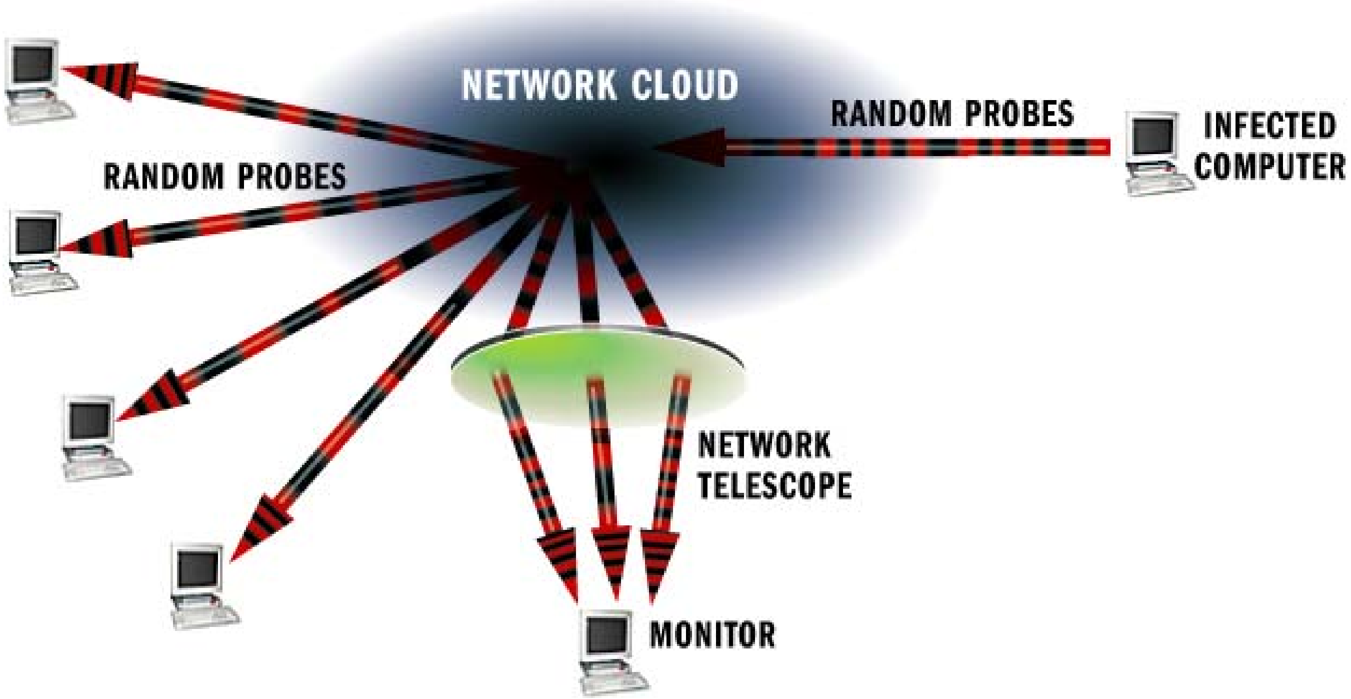
- http://www.caida.org/data/realtime/telescope/
- Prevalence and trends in spoofed-source denial-of-service attacks
  - http://www.caida.org/data/realtime/telescope/?monitor =telescope_backscatter
- (live demo)

What is a Network Worm?

- Self-propagating self-replicating network program
  - Exploits some vulnerability to infect remote machines
    - No human intervention necessary
  - Infected machines continue propagating infection



Network Telescope: Worm Attacks



- Infected host scans for other vulnerable hosts by randomly generating IP addresses
- We monitor 1/256th of all IPv4 addresses
- We see 1/256th of all worm traffic of worms with no bias and no bugs

Witty Worm Background

March 19, 2004

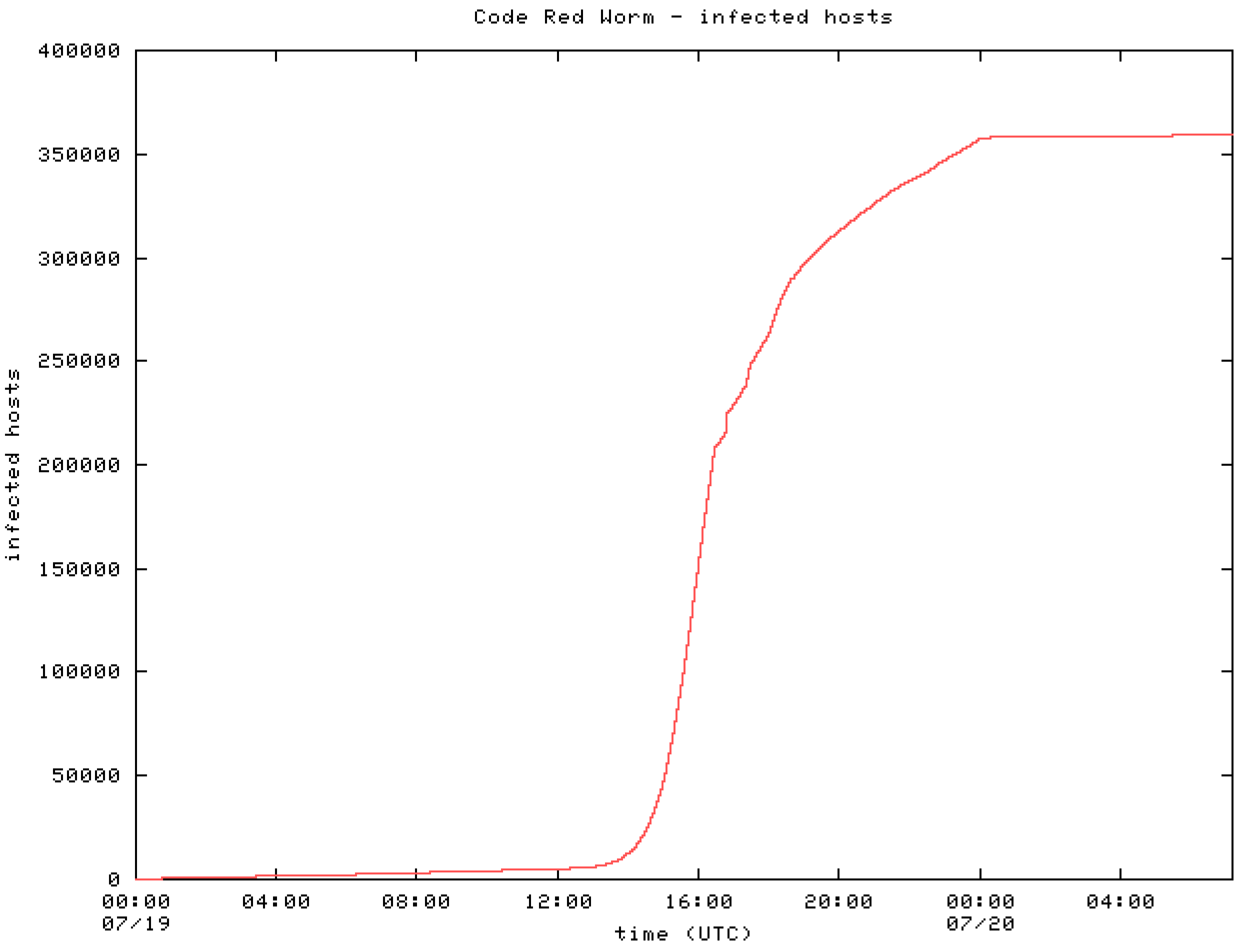
- ISS Vulnerability
  - – A buffer overflow in a PAM (Protocol Analysis Module) in a Internet Security Systems firewall products
    - Version 3.6.16 of iss-pam1.dll
  - – Analyzes ICQ traffic (inbound port 4000)
  - – Discovered by eEye on March 8, 2004
  - – Jointly announced March 18,2004 when “patch” available
    - Upgrade to the next version at customer cost…
- By far the closest to a zero-day exploit
  - – Instead of 2-4 weeks after bug release, Witty appeared after *36 hours*

Witty Worm Structure

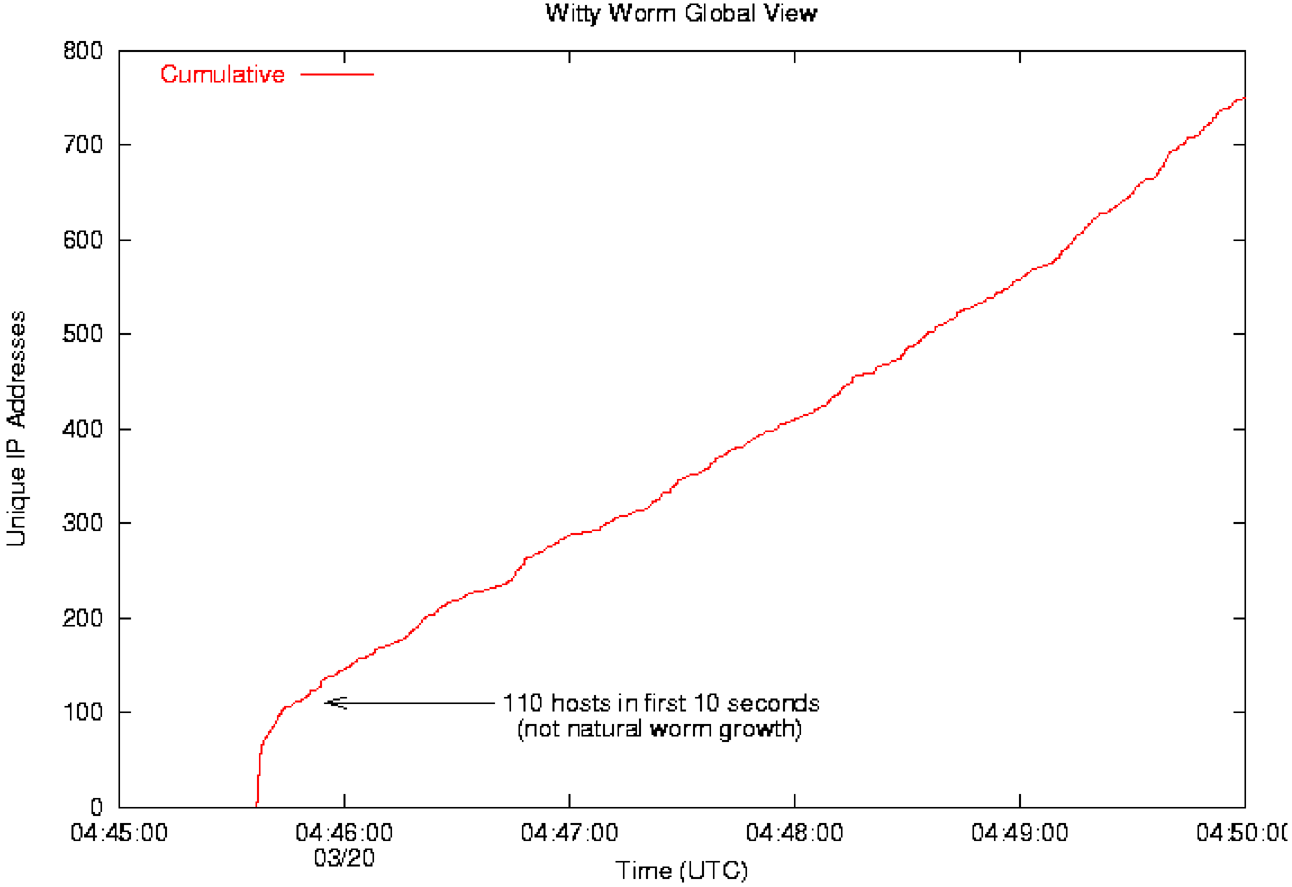
March 19, 2004

- Infects a host running an ISS firewall product
- Sends 20,000 UDP packets as quickly as possible:
  - to random source IP addresses
  - to random destination port
  - with random size between 796 and 1307 bytes
- Damage Victim:
  - select random physical device
  - seek to random point on that device
  - attempt to write over 65k of data with a copy of the beginning of the vulnerable dll
- Repeat until machine is rebooted or machine crashes irreparably

Typical (Code-Red) Host Infection Rate



Early Growth of Witty (5 minutes)

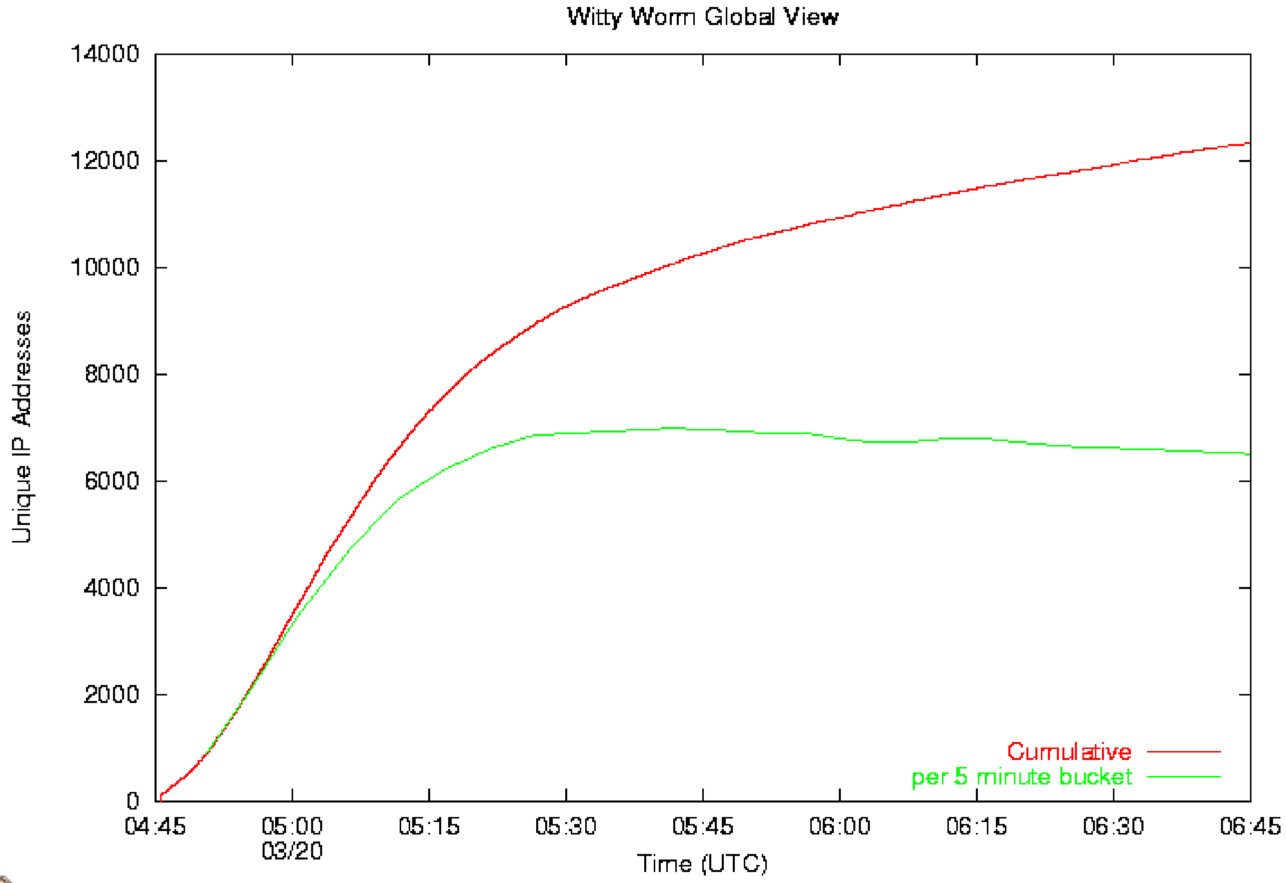


Witty Worm Spread

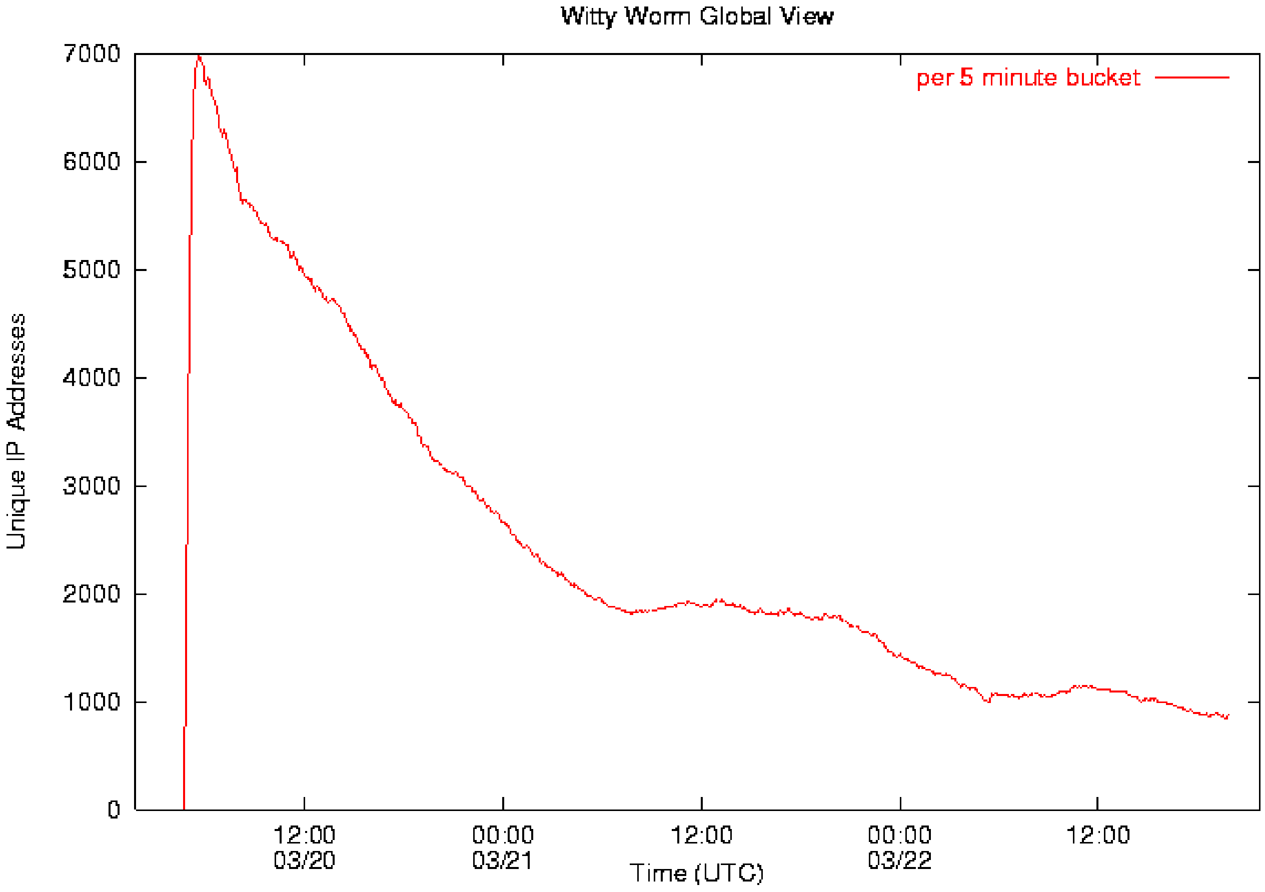
March 19, 2004

- Sharp rise via initial coordinated activity
- Peaked after approximately 45 minutes
  - Approximately 30 minutes later than the fastest worm we’ve seen so far (SQL Slammer)
  - Still far faster than any human response
  - At peak, Witty generated:
    - 90 GB/sec of network traffic
    - 11 million packets per second

Early Growth of Witty (2 hours)



Early Growth of Witty (3 days)



Witty Worm Victims

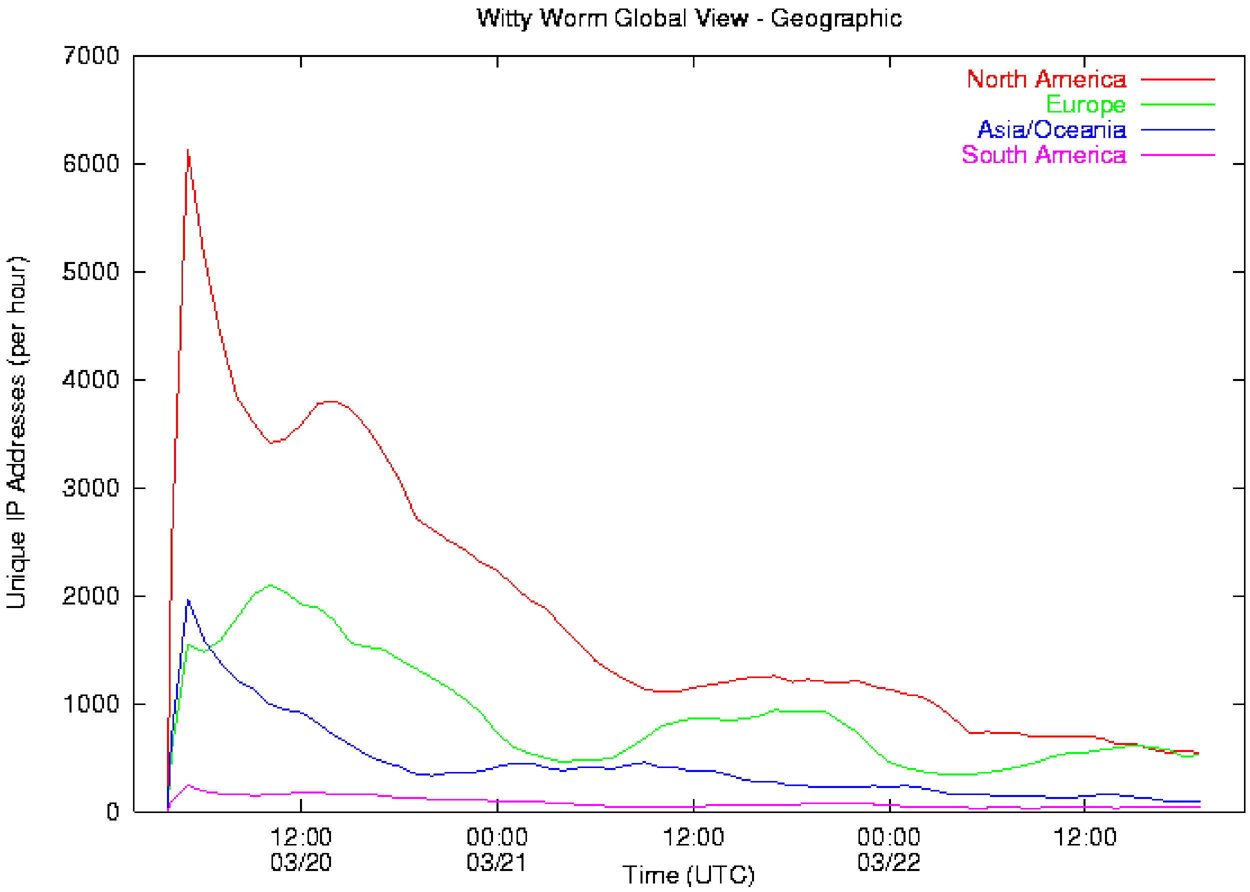
- Consistent with past worms:
  - Globally distributed
  - Majority high-bandwidth home/small business users
- Unique victim characteristics
  - 100% taking proactive security measures
  - Infected via software they ran purposefully

Witty Worm Victims

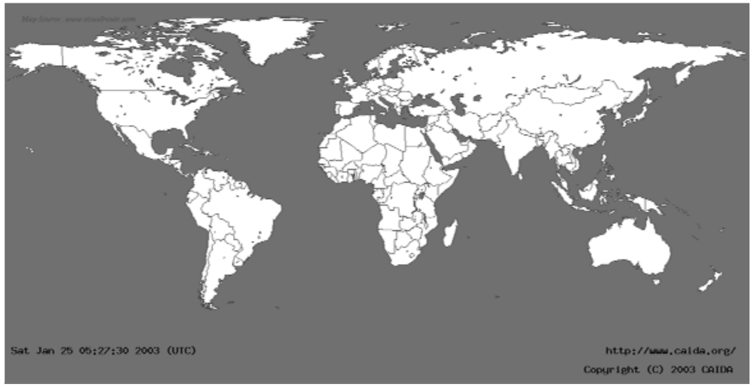
Country	Percent
United States	26.28
United Kingdom	7.27
Canada	3.46
China	3.36
France	2.94
Japan	2.17
Australia	1.83
Germany	1.82
Netherlands	1.36
Korea	1.21

TLD	Percent
com	33
net	20
no-DNS	15
fr	3
ca	2
jp	2
au	2
edu	1
nl	1
ar	1

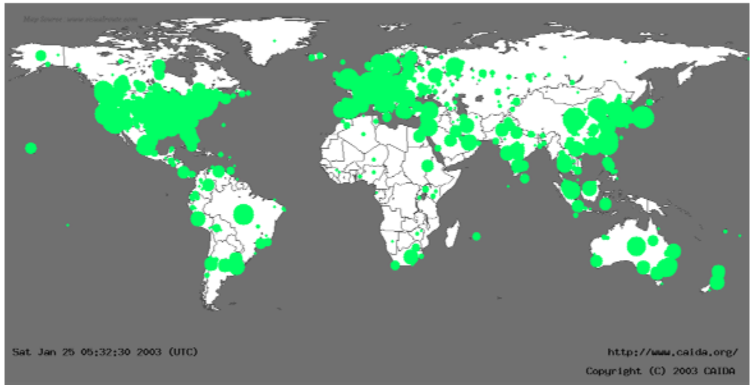
Geographic Spread of Witty



Witty Summary



Before 9:30PM (PST)



After 9:45PM (PST)

- ~12,000 hosts infected in **30 minutes**
- Averaged more than 11 million probes per second world-wide
- Unstoppable
- Irreparably destroyed a significant number of infected computers

Conclusions (1)

- Witty incorporates a number of novel and disturbing features:
  - – Next day exploit for publicized bug
  - – Wide-scale deployment
  - – Successful exploit of small population (no more security through obscurity)
  - – Future worms will continue to emulate botnets – increasing levels of stealth and flexibility
  - – Infected a ***security*** product

Conclusions (2)

- Witty demonstrates conclusively that the patch model of networked device security has failed
  - You can’t encourage people to sign on to the ‘net with one click and then also expect them to be security experts
  - Running commercial firewall software at their own expense is the gold standard for end user behavior
    - Recognition that security is important
    - Recognition that they can’t do it themselves

Conclusions (3)

- End-user behavior cannot solve current software security problems
- End-user behavior cannot effectively mitigate current software security problems
- We must:
  - Actively address prevention of software vulnerabilities
  - Turn our attention to developing large-scale, robust, reliable infrastructure that can mitigate current security problems without end-user intervention

About Blackworm

- Began to spread January 15, 2006
- 95k Visual Basic executable email attachment run by users
- Also spread to attached network shares
- Malicious: on the 3rd day of every month:
  - searches for files with 12 common file extensions (.doc, .xls, .mdb, .mde, .ppt, .pps, .zip, .rar, .pdf, .psd, and .dmp)
  - replaces those files with the text string "DATA Error [47 0F 94 93 F4 K5]"

So who cares?

- Blackworm is not particularly different from many, many other email viruses, except…
- Every infected computer automatically generates an http request for a web page that displayed a hit count graph (self-documenting code?)
- Logs for the website were available before the first date of payload destruction
- **Some victims could be notified before they lost data**

Log Analysis

- Simple! Just take the logs and look at who connected and you’ll have the infected IP addresses!
- Except that the url was publicized…
- Many folks looked at the page to observe the spread of the virus
- Denial-of-service attacks added a large volume of spurious traffic

Log Filtering

- Why not just count IP addresses that were logged once?
- Web traffic aggregators (NAT, proxy servers) obscure victim IP addresses; multiple probes can represent mulitple infections
- DHCP use allows two different computers to have the same IP at the time that they become infected

Log Filtering Process

- Remove referer/browser strings set by common DDoS tools (91.1% of all hits)
- Remove requests for pages different from the one accessed by the virus (0.2%)
- Remove any request with a referer string (virus did not use one in its probes) (0.8%)
- Remove requests from invulnerable Operating Systems: MacOS, Unix, cell phone, and PDA devices (0.03%)

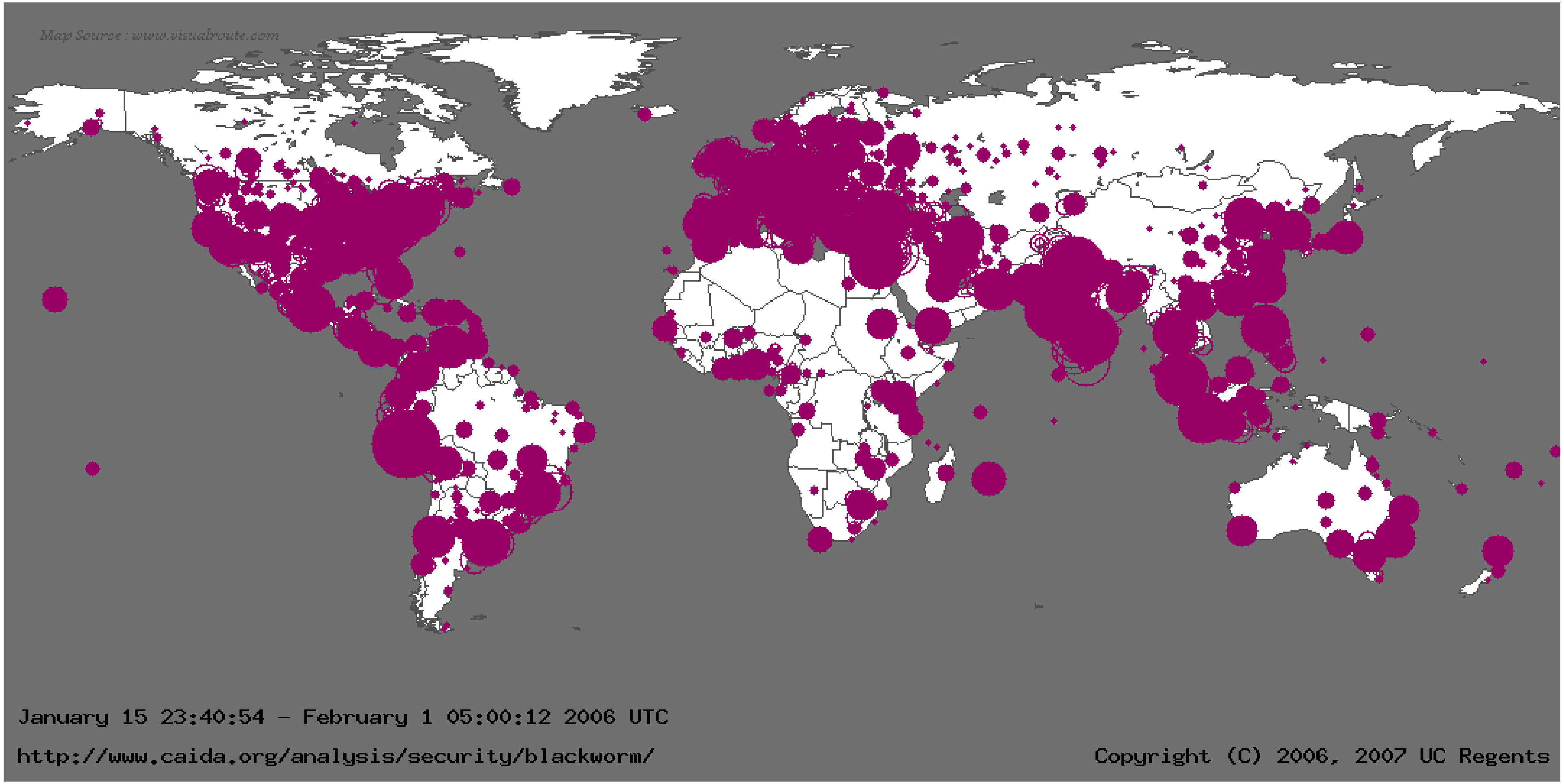
Sources of Error and Uncertainty

- Infected computers that failed to send the probe
- Network firewalls or outages that prevented victims from reaching the web page
- Denial-of-Service attacks preventing infected computers from reaching the web page
- People who viewed the counter only once using a vulnerable browser, but were not infected

Estimating a Victim Count

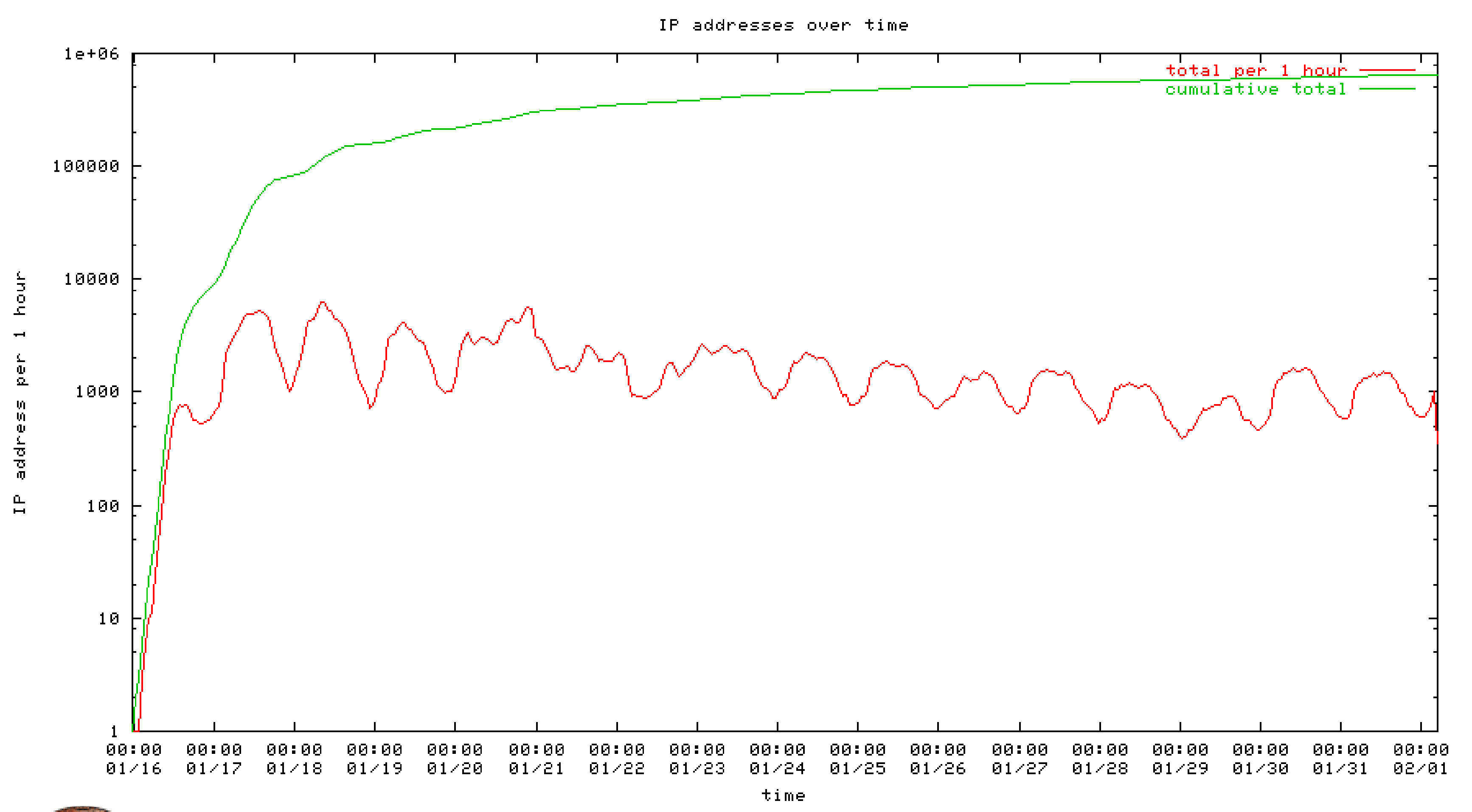
- Lower bound: for each IP address, the number of unique, vulnerable browser types received from that IP address

- Upper bound: for each IP address, the total number of probes received from that IP address

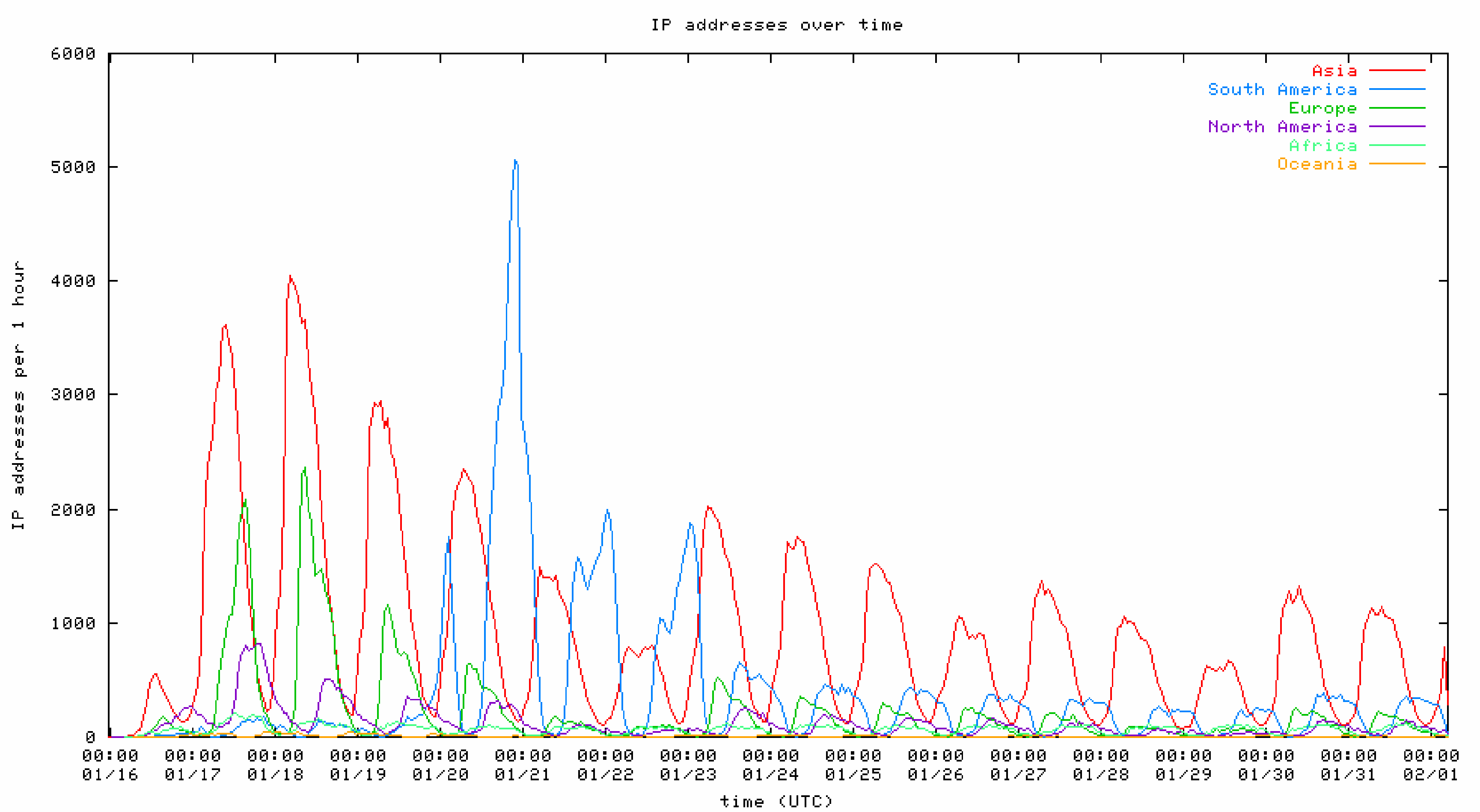

Map Source : www.visualroute.com
January 15 23:40:54 - February 1 05:00:12 2006 UTC
http://www.caida.org/analysis/security/blackworm/
Copyright (C) 2006, 2007 UC Regents

- Blackworm victim estimate: between 469,507 and 946,835 (3.2%-6.4% of original log entries)

Blackworm Overall



Blackworm by Continent



caida

Cooperative Association for Internet Data Analysis

Blackworm by Country (>2%)

Country	Min. Count	Min %	Max Count	Max %
India	151341	32	273013	29
Peru	87599	19	150785	16
Italy	38216	8	58002	6
Turkey	28264	6	43437	5
USA	26315	6	58791	6
Egypt	12201	3	25104	3
Malaysia	11160	2	19942	2

Concurrent Infections

- 45,401 Blackworm victims (10%) had concurrent spyware and/or botnet infections advertised in their browser string

  -
    ```
    Mozilla/4.0 (compatible; MSIE 5.5; Windows 98;
    Sgrunt|V109|29|S493689067|dial; FunWebProducts;
    XBE|29|S04069679521143#398|isdn;
    snprtz|S04138822910124)
    ```

Cuttlefish Animation…

Conclusions

- Log analysis allows insight into email virus spread given sufficient data mining
- Email viruses spread in a slower and steadier pattern than Internet worms, which infect the vast majority of their victims in the first day
- Diurnal patterns are strongly apparent in spread data (people read their email when they are awake)

Conclusions (2)

- Country distribution of victims does not correlate with web infrastructure development
- Spread strongly influenced by geographic location (based on social and linguistic similarity)
- TLD distribution reflects geographic distribution rather than # of vulnerable hosts/TLD
- 10% of victims had concurrent botnet or spyware infection

Botnets

- Significant transition in motivation for widespread, non-specific malicious activity
  - From notoriety -> want to be noticed
  - To money -> want stealth to protect revenue stream

- So how do you make money?
  - Sending spam
  - DoS extortion
  - Active (phishing) and passive identity theft

Current Events

- Malicious software development is a business aimed at scalable, manageable distributed systems
- Coordinated activity makes current antivirus activities increasingly irrelevant
- Demise of signature-based security?
- High system complexity + naïve/uneducated = bad combination

Current Security Research

- Longitudinal study of Blackworm
- Spamscatter
- Botnet Economics
- Worm Risk Analysis
- Anomaly Detection

CAIDA Security Datasets

- Freely available datasets (no IP addresses):
  - Code-Red Worm
  - Witty Worm
- Academic / Non-profit access datasets:
  - Denial-of-service attack backscatter
  - Witty Worm
  - OC48 peering point traces (many contain attacks; also provide real background traffic for testing detection/mitigation technology)

DatCat

Internet Measurement Data Catalog

http://imdc.datcat.org